Fuel Cells & Hydrogen Joint Undertaking 2

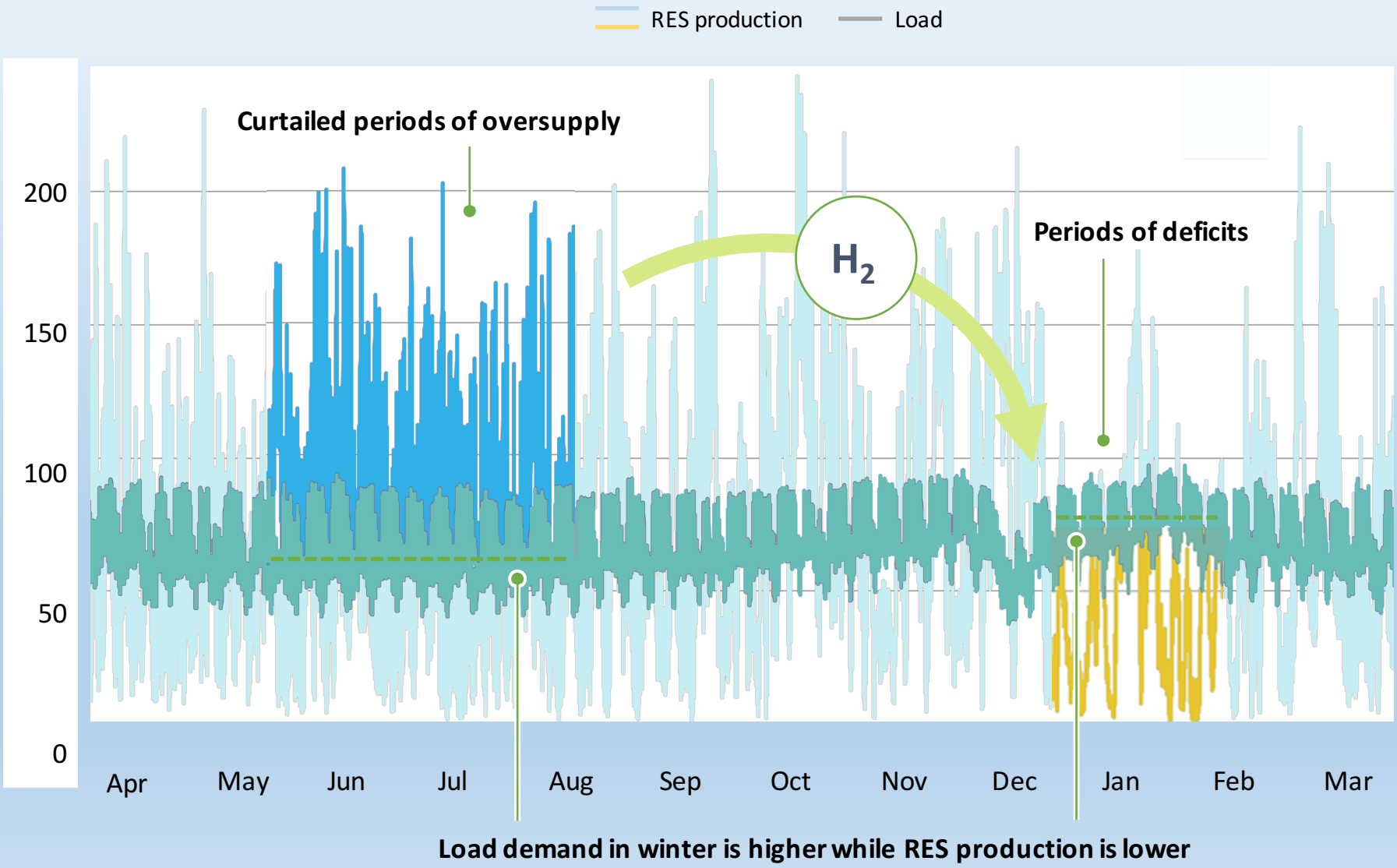
Industry Grouping
Hydrogen Europe

European Union
represented by the European Commission

Research Grouping
(former N.ERGHY)

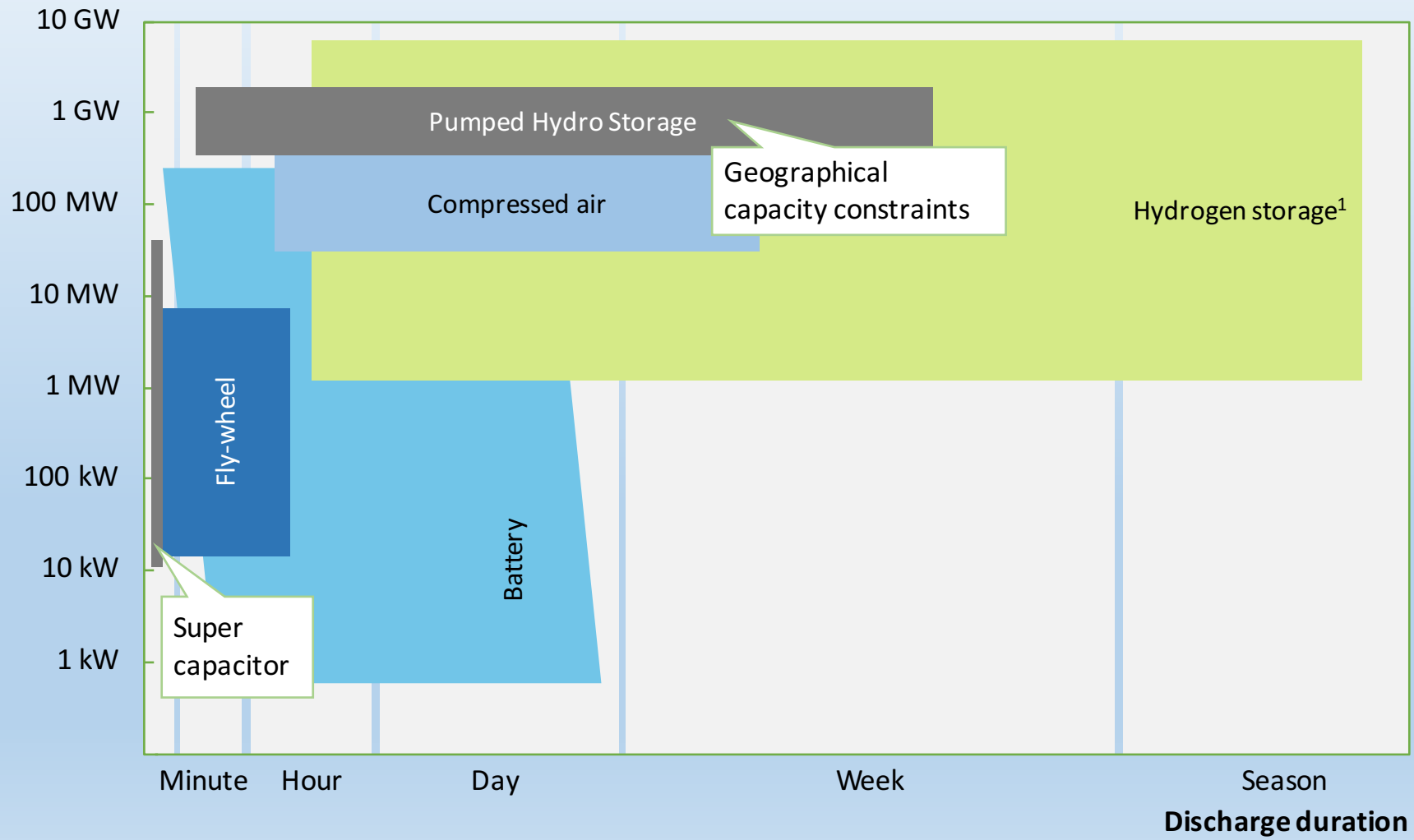
A portfolio of clean, efficient and competitive solutions based on fuel cells and hydrogen technologies **in energy and transport**

Hydrogen enables seasonal storage avoiding massive curtailment



Source: EC 2050 scenario, McKinsey analysis

Hydrogen for long-term carbon-free energy storage



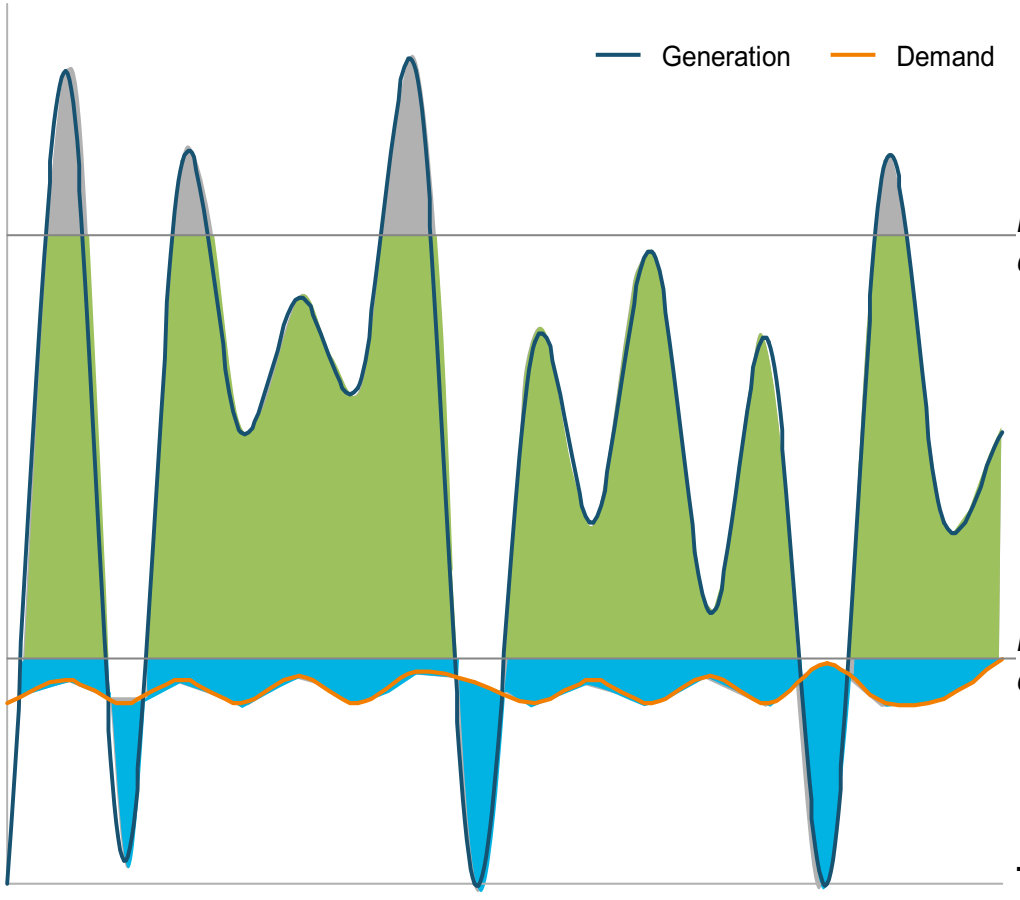
1 IEA data updated due to recent developments in building numerous 1MW hydrogen storage tanks

Source: IEA Energy Technology Roadmap Hydrogen and Fuel Cells, JRC Scientific and Policy Report 2013

Hydrogen storage bridges gaps in supply and demand

Electricity supply and demand, TWh

ILLUSTRATIVE



Means of balancing

Curtailment of extreme peaks

Hydrogen used for

- **Long-term storage** to balance across weeks and seasons
- **Transfer** of renewable energy to other sectors
- Transfer to other **regions** where electricity transmission not sufficient/ not cost efficient

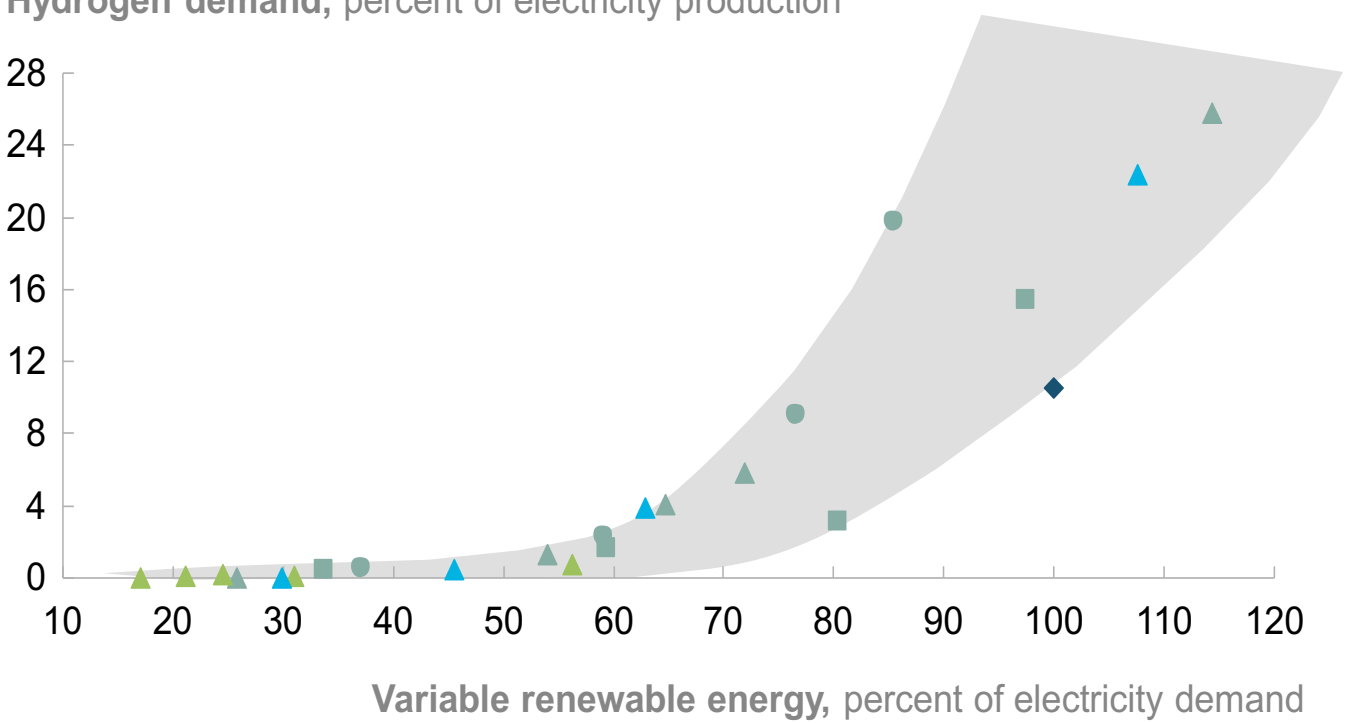
Batteries and power balancing[1]**:** Short-term storage to balance within hour/day

1 Demand-side load balancing, etc.

SOURCE: McKinsey

Hydrogen storage increases exponentially with the variable energy share

Overview of study results



Colors

- Germany
- Sweden
- Spain
- Europe

Shapes

- ○ Fraunhofer (storage & sector coupling)
- △ McKinsey
- ◇ RWTH Aachen (power only)
- □ Sterner & Stadler[3] (mean)

1 Simulation of Germany Energy Systems; most-efficient/least-cost modeling to achieve 2 degree scenario in Germany in 2050 based on hour-based simulation of electricity generation and demand; no regional distribution issues assumed (would rather increase need for storage), no increases/ decreases in energy imports and exports

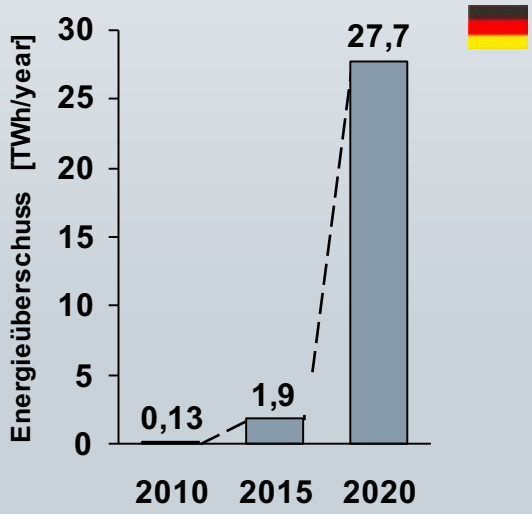
2 Simulation of storage requirements for 100% European RES; considers only storage for power sector, could be considered a lower bound for total hydrogen pathway

3 Converted to shares based on projections of total power demand until 2050

SOURCE: Fraunhofer , BMW, RWTH Aachen, Sterner und Stadler (2014): Energiespeicher - Bedarf, Technologien, Integration, McKinsey

Excess RE production could feed FCEVs
German Example

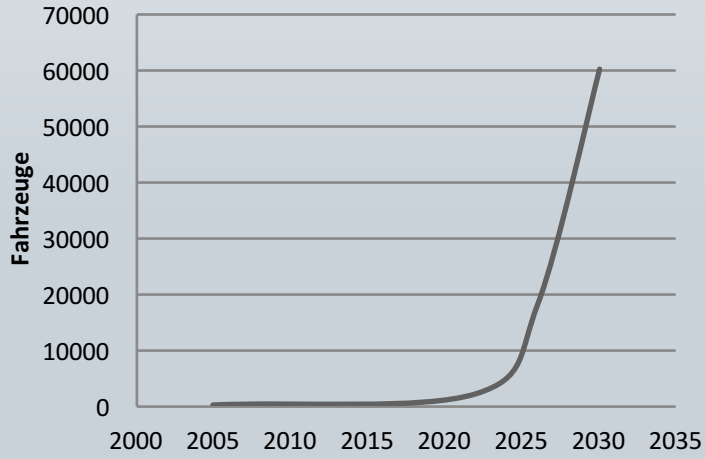
- Aussagen zur Überschussproduktion durch Erneuerbare Energien differieren deutlich. Die Spannweite reicht von 0 (DENA, BCG) bis >40 TWh für 2030.



Quelle: EnBW (Münch), BMU Strategie-Workshop, 05.09.12

1 TWh Überschussproduktion ist äquivalent zu (**2015: 4,7TWh in D**):

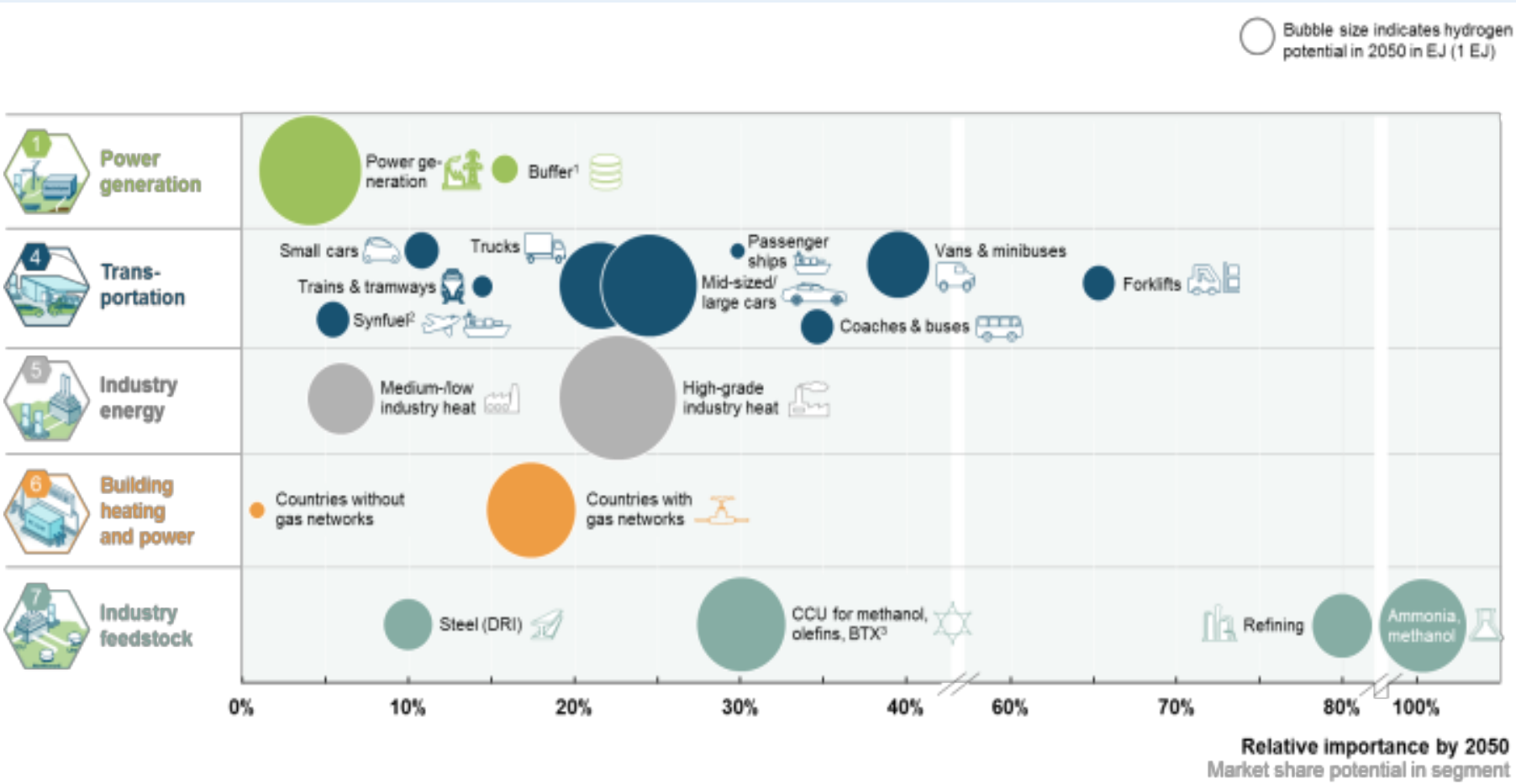
- ≈ 20.000 t H_2
- ≈ 2 Mrd km H_2-Mobilität (@ 1kg/100 km)
- ≈ 150.000 Brennstoffzellenfahrzeuge (@ 14.000 km/y) **(705.000 FCEVs in 2015)**



Prognose für Bestand von FCEV Fahrzeugen

Bei Eintreten DENA Maximalszenario (40TWh) wäre theoretisch die Versorgung von bis zu 6 Mio. FCEV in 2030 möglich

Hydrogen plays a critical role in low-carbon tech portofolio

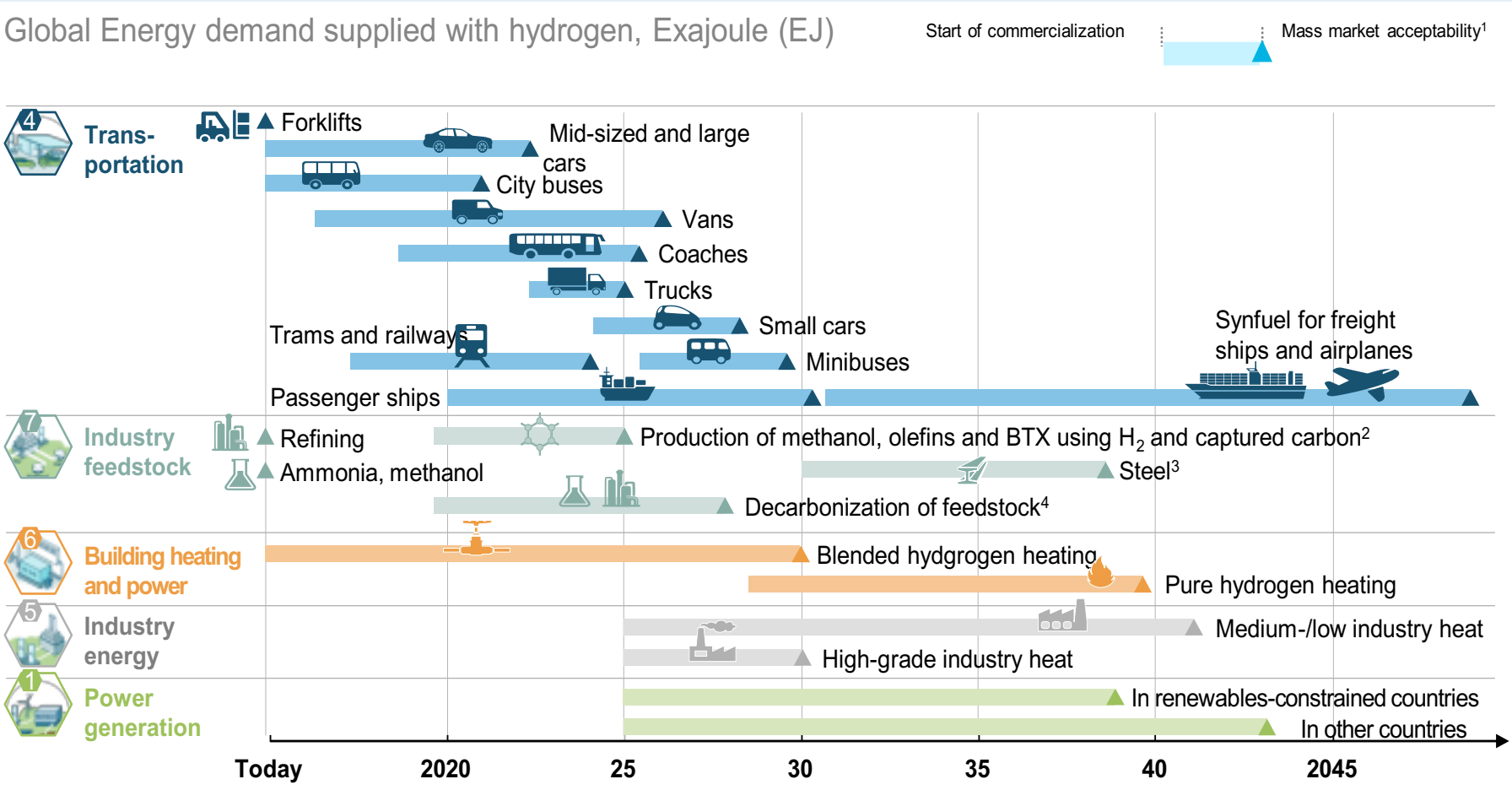


1 Percent of total annual growth in hydrogen and variable renewable power demand
2 For aviation and freight ships
3 Percent of total methanol, olefin, BTX production using olefins and captured carbon

SOURCE: Hydrogen Council

Hydrogen technology ready for deployment

Hydrogen Europe

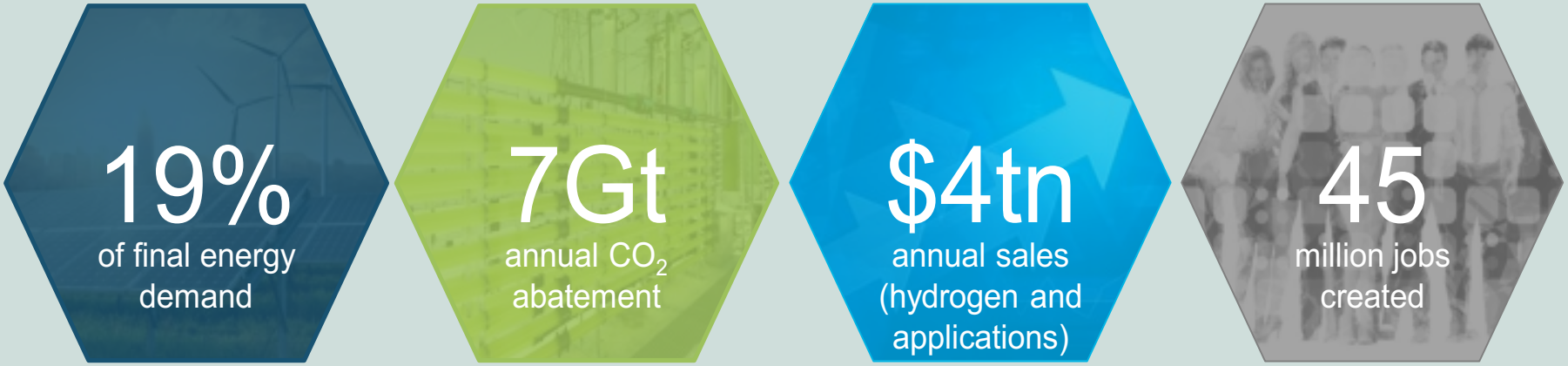


1 Mass market acceptability defined as sales >1% within segment in priority markets
2 Market share refers to the amount of production that uses hydrogen and captured carbon to replace feedstock
3 DRI with green H_2, iron reduction in blast furnaces and other low-carbon steel making processes using H_2
4 Market share refers to the amount of feedstock that is produced from low-carbon sources

SOURCE: Hydrogen Council

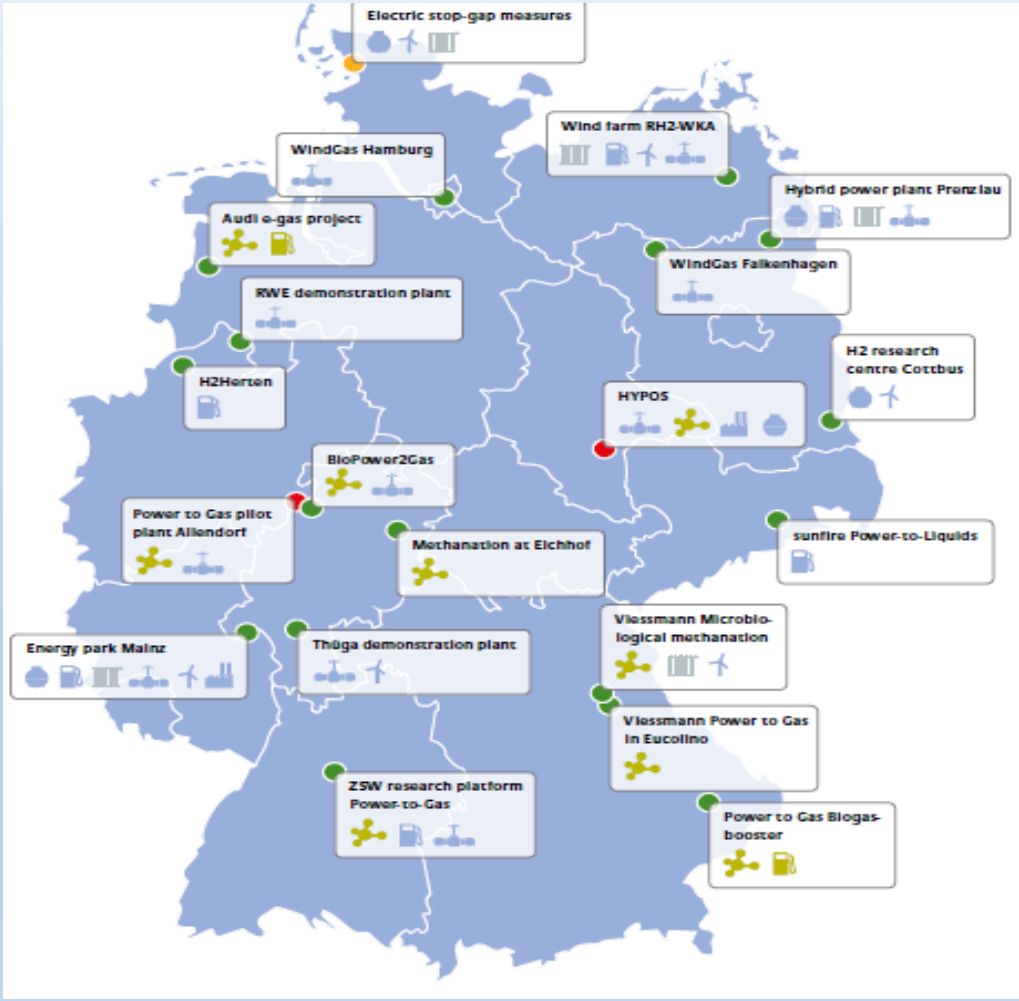
Hydrogen vision for 2050

2050 hydrogen vision (annual figures for 2050)



SOURCE: Hydrogen Council, IEA ETP Hydrogen and Fuel Cells CBS, National Energy Outlook 2016”

Reality check: “Power to gas“ projects



Project status	Legend	Gas
In operation	Methanation	Hydrogen
Under construction	Feed-in into the gas network	Methane
Planning phase	Reconversion	
	Heat generation	
	Gas storage	
	Fuel	
	Material use	

It is happening ! It can be done !

Summary: How to kick-off the hydrogen economy?

- Uptake of hydrogen in industry and power production at large requires hydrogen to be cost-competitive with current processes and fuels.
- A reform of the energy market in terms of feed-in tariffs, curtailment management, seasonal balancing remuneration and carbon pricing can accelerate the competitiveness.
- Similar arrangements to digressive feed-in tariffs could go a long way in promoting clean hydrogen production and use.
- Clear national (EU) action plans for the development of hydrogen within and across sectors can kick-start the roadmap.

(SOON **Sectoral integration**)

EU Commission more and more believes in hydrogen